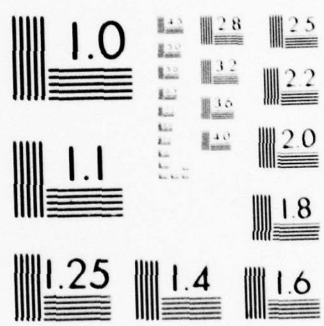
AD-A068 723 ARMY ELECTRONICS RESEARCH AND DEVELOPMENT COMMAND WS--ETC F/G 3/3
SOLAR ECLIPSE 1979. ATMOSPHERIC SCIENCES LABORATORY PROGRAM OVE--ETC(U)
FEB 79 M G HEAPS, R O OLSEN, W W BERNING

UNCLASSIFIED ERADCOM/ASL-TR-0026 NL

1 OF 1
AD A068723

END
DATE
FILMED
6-79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD

Reports Control Symbol
OSD - 1366

ASL-TR-0026

AD A068723

SOLAR ECLIPSE 1979

ATMOSPHERIC SCIENCES LABORATORY PROGRAM OVERVIEW

LEVEL II

FEBRUARY 1979

By

MELVIN G. HEAPS

ROBERT O. OLSEN

US ARMY ATMOSPHERIC SCIENCES LABORATORY

WHITE SANDS MISSILE RANGE, NM 88002

WARREN W. BERNING

PHYSICAL SCIENCES LABORATORY

NEW MEXICO STATE UNIVERSITY

LAS CRUCES, NM 88003

Approved for public release; distribution unlimited

US Army Electronics Research and Development Command

Atmospheric Sciences Laboratory

White Sands Missile Range, NM 88002

NOTICES

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The citation of trade names and names of manufacturers in this report is not to be construed as official Government indorsement or approval of commercial products or services referenced herein.

Disposition

Destroy this report when it is no longer needed. Do not return it to the originator.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ASL-TR-0026	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 SOLAR ECLIPSE 1979. Atmospheric Sciences Laboratory Program Overview.		5. TYPE OF REPORT & PERIOD COVERED R&D Technical Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Melvin G. Heaps, Robert O. Olsen Warren W. Berning*		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Atmospheric Sciences Laboratory White Sands Missile Range, New Mexico 88002		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 16 DA Task No. 1L161102B53A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Electronics Research and Development Command Adelphi, MD 20783		12. REPORT DATE 11 February 1979
		13. NUMBER OF PAGES 39
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) 14 ERADCOM/ASL-TR-0026		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

9 Technical rept. 12 40p.

18. SUPPLEMENTARY NOTES

*Physical Sciences Laboratory
New Mexico State University
Las Cruces, NM 88003

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Solar eclipse
D-region
Middle atmosphere
Electron density
Measurements program

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The 1979 solar eclipse provides a unique opportunity to better understand the interrelationship of many factors which influence the chemical, physical, and electrical structure of the earth's middle atmosphere. An eclipse provides a day-"night"-day transition on the time scale of a few minutes, thus allowing the rapid processes which affect the electron and ion chemistry to be monitored, while assuring that the bulk properties of the neutral atmosphere vary in a regular and predictable manner. Experimental findings from past eclipses have over

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

79 05 18 059

410 663

20. ABSTRACT (cont)

indicated that a very rapid electron attachment/detachment process exists in the D-region which is not reproduced in our present models and yet needs to be explained because of its potential impact on Army communication systems and nuclear weapons effects studies. To better understand these properties of the middle atmosphere, the Atmospheric Sciences Laboratory is helping to coordinate a field experiment program for the 26 February 1979 solar eclipse.

SUMMARY

The 1979 solar eclipse provides a unique opportunity to study the interrelationship of many factors which control the chemical, physical, and electrical structure of the earth's middle atmosphere. Past measurements have shown the presence of an electron attachment process and possible electron storage mechanism which are of importance to Army communications and nuclear weapons effects studies. To correctly model and predict the effects of such electron processes, a broad and interrelated data base is needed; therefore, the Atmospheric Sciences Laboratory (ASL) is helping to coordinate a field measurements program for the 26 February 1979 solar eclipse.

In cooperation with the National Research Council (NRC) of Canada and the National Aeronautics and Space Administration (NASA), a field experiment site has been selected in the Red Lake area of western Ontario, Canada. This area offers the advantages of necessary land area for a rocket program, reasonable support facilities to reduce logistical considerations, and maximum duration of eclipse totality at the altitudes of interest.

The main areas of emphasis for ASL participation are the variations in electron density and electrical structure during the course of the eclipse. But a more thorough understanding of such phenomena also demands a knowledge of the sources of ionization in the middle atmosphere and the identity and time variations of the ions and minor neutral species. To gather this type of data, ASL is sponsoring several types of rocket payloads. Two payloads, to be flown from the large rocket range, will measure both photon and particle ionization sources, electron density, and densities of several neutral species Four small rocket probes will be used to measure atmosphere temperature and pressure. In addition a ground-based partial reflection sounder will be operated to provide continuous monitoring of D-region electron densities

The ASL program is being coordinated with the experimental programs of the Air Force Geophysics Laboratory (AFGL), NASA, and NRC of Canada. Thus, many complementary and supplementary measurements can be provided to all participants at major cost savings. This cooperative effort is then able to provide a broad spectrum of data which can be used to substantially further our knowledge of the middle atmosphere and predict its effect on Army communications and radar systems.

CONTENTS

On 26 February 1979, a total eclipse of the sun will occur over the northwestern tier of the United States and the Canadian provinces of Monitoba and Ontario. This will be the last total eclipse observable from the North American continent in this century and presents a unique opportunity to mount a coordinated field program without formidable logistical costs.

Interest in monitoring solar eclipses has grown in the last 15 years as experimental methods have become available for in situ probing of the middle and upper atmosphere. The first direct measurements of the D-region during an eclipse were carried out in 1963[1] and showed a (heretofore unexpected) very large decrease in electron densities below 75 km near the maximum phase of the eclipse. Subsequent and improved measurements during the 1966 and 1970 eclipses have confirmed the anamolous behavior of the electron density while tentatively identifying some of the positive ions present in the D-region. Army involvement during past eclipse programs has centered on both the chemical and physical state of the middle atmosphere as well as its electrical structure.[2-5]

Major questions which have been raised by past experimental findings, and are still unanswered, concern the rapid decrease in D-region electron densities at totality and an anamolously large positive ion to electron density ratio. The implications are that there exists an as-yet-undetermined rapid electron attachment/detachment process in the D-region of the middle atmosphere. This process needs to be determined and its effects incorporated in Army communication systems prediction computer codes and nuclear weapons effects simulation codes.

---

[1]L. G. Smith, C. A. Accardo, L. H. Weeks, and P. J. McKinnon, 1963, "Measurements in the Ionosphere During the Solar Eclipse of 20 July 1963," J Atmospheric Terrest Phys, 27:803-829

[2]H. T. Lootens, and W. A. Dean, 1970, "D-Region Electron Density Measurements During the Solar Eclipse of 12 November 1966," BRL Report 1464, US Army Ballistic Research Laboratories, Aberdeen Proving Ground, MD

[3]H. N. Ballard, J. S. Randhawa, and W. L. Webb, 1968, "Stratospheric Circulation Response to a Solar Eclipse," R&D Report, ECOM-5189, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

[4]J. S. Randhawa, 1968, "Mesospheric Ozone Measurements During a Solar Eclipse," J Geophys Res, 73:493-495

[5]H. N. Ballard, R. Valenzuela, M. Izquierdo, J. S. Randhawa, R. Morla, and J. F. Bettle, 1969, "Solar Eclipse: Temperature, Wind, and Ozone in the Stratosphere," J Geophys Res, 74:711-713

The desired outcome of a research plan to measure response of the atmosphere to a solar eclipse is the production of improved atmospheric models with which to predict atmospheric response under a variety of disturbances. In developing a research program for the solar eclipse, principal interest centers upon the behavior of the ionized regions at altitudes below 100 km which are of concern to Army HF communication systems and nuclear weapons effects predictions. Therefore, to better understand and define the middle atmosphere and its electrical structure, ASL is assisting in coordinating and mounting a basic field experiment program to study the 26 February 1979 solar eclipse.

DESCRIPTION OF ECLIPSE PATH AND LAUNCH SITES

The solar eclipse of 26 February 1979 begins at dawn over the Pacific Ocean west of Puget Sound and will terminate at sunset over northern Greenland. Because of the northerly path of totality and the calendar date of occurrence, solar elevation angles for observing sites along the totality path will not exceed 26 degrees, a factor of importance in planning for eclipse related experiments. The portion of the eclipse path which lies over North America is shown in figure 1. Particulars for the eclipse path at equally spaced points (in time) are given in table 1 for the numbered points in figure 1.

Early consideration of the scientific objectives deriving from the major concern for understanding atmospheric response dictated a site for rocket experiments for which the solar elevation angle was near its maximum value. This constraint arises because the earth's atmosphere between the sun and point of measurement provides a filter for incoming solar radiation which blocks or decreases the energy input into the atmosphere and thus modifies the atmospheric response of primary interest. Referring to figure 1 and table 1, the solar elevation angle attains its maximum value between northeastern Montana and the shore of the Hudson Bay.

In the absence of existing and suitable sounding rocket installations, operating safety constraints imposed by existing population centers and rural populations are exceedingly severe. Combining safety, the equally restrictive logistic problems and the eclipse totality requirements for the rocket measurements quickly removed all but a few potential sites for rocket operations. In cooperation with NRC of Canada and NASA, several potential sites were surveyed, with final site selection settling on the Red Lake area in western Ontario, Canada.

Six physically separate locations in the Red Lake area will be used during various phases of the 1979 solar eclipse program. Three locations are near Red Lake itself and are more closely associated with the small rocket program, while the three remaining locations are approximately 30 km southeast of Red Lake and are associated with the large rocket program. Figure 2 shows these locations in greater detail.

The small rocket launch site is located just north of the town of Cochenour and will be utilized by ASL and the NRC of Canada. About 2 km south is the small rocket instrumentation and tracking site, located at the physical plant of Cochenour-Willans Mine. Additional buildings at the Cochenour-Willans Mine are to be used as the "command center" for the coordination of the eclipse program. The partial reflection sounder is located in Balmertown.

The large rocket instrumentation site and launch site are located approximately 30 km southeast of Red Lake and Balmertown. The launch site is separated from the instrumentation site about 6 km on an east-west line across the Chukuni River. These sites are to be used by ASL, the AFGL, and NASA. Somewhat further southeast on the main highway is the rocket booster storage and large rocket assembly area located in a building at the Griffith Mine.

Because of the small angle (26 degrees) that the sun makes with the horizon during totality in the Red Lake area, and hence because of the rather oblique shadow through the atmosphere, it is advantageous to have the rocket launch sites located on the southern edge of the area of totality at ground level, as is illustrated in figure 3. This allows the lower ionosphere above the rocket launch sites to be along the center line of totality, thus enabling the in situ sampling to be done where the duration of the total eclipse is longest. The specifics of the onset and duration of the eclipse at the small and large rocket sites are given in table 2.

SCIENTIFIC NEEDS AND REQUIREMENTS

The basic objective of the 1979 solar eclipse field measurements program is to provide the necessary measurements to improve the understanding of the chemical and physical properties of the middle atmosphere. Of particular interest is the electrical structure and variations in electron density of the D-region. Data from previous measurements, such as those from the 1966 solar eclipse illustrated in figure 4, have shown a significant decrease in electron concentration during the short time about totality. (In figure 4, 2C denotes second contact or onset of totality and 3C denotes third contact or end of totality.) Ideally one's knowledge of atmospheric processes should be complete enough to simulate and predict such variations in electron density. Using a current model of the pertinent atmospheric chemistry,[6] the data from figure 4 is shown again in figure 5 along with the simulated electron densities. The disparity is most

---

[6]D. W. Hoock, and M. G. Heaps, 1978, "DAIRCHEM: A Computer Code to Model Ionization-Deionization Processes and Chemistry in the Middle Atmosphere," ASL Internal Report, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

dramatic. Detailed studies[7,8] of this phenomenon have concluded that it cannot be explained by the currently known, conventional gas phase chemistry. The data indicate that a rapid electron attachment/detachment process exists which is not well understood.

A coordinated set of measurements is needed to improve models of atmospheric response to various disturbances, both natural and man-made. Credible models are needed whether the concern is a decrease in the stratospheric ozone shield or serious impairment in radiowave communications. The extremely rapid loss of electrons at second contact during the 1966 eclipse raises the possibility of an electron storage mechanism over a broad altitude regime rather than permanent electron removal through electron-ion recombination. As a consequence, reinstitution of sunlight would release the stored electrons and provide a degraded or markedly changed environment for the transmission of radio signals from ELF to HF frequencies. Such a phenomenon was observed after the high altitude nuclear tests in the Pacific in 1958. High altitude nuclear events are not required; large-yield surface bursts will produce the same effect but at even lower altitudes than observed in 1958. Thus, predictive models of atmospheric response have practical application to real problems today. Significantly, only the measurements taken during an eclipse have shown the phenomenon of rapid electron loss which is completely unexplained by existing models of atmospheric response.

To provide a sufficient data base the following types of measurements are required.

a. Electron density variations in the period about totality

b. Positive and negative ion composition and densities in the period about totality

c. Ionizing radiations (background and eclipse modulated)

d. Density of important minor neutral species (background and eclipse modulated)

e. Possible presence of aerosols and their properties

f. Temperature and density

g. Direct and scattered solar flux at selected wavelengths

---

[7]M. G. Heaps, F. E. Niles, and R. D. Sears, 1978, "Modeling the Ion Chemistry of the D-Region: A Case Study Based Upon the 1966 Total Solar Eclipse," ASL-TR-0015, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

[8]M. G. Heaps, 1978, "The 1979 Solar Eclipse and Validation of D-Region Models," ASL-TR-0002, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM

To make the necessary measurements and yet provide the needed redundancy and backup, a coordinated experimental program has evolved between ASL and AFGL, as Department of Defense participants, NASA and NRC of Canada. While such a program necessarily reflects the interests and desires of various researchers and groups, it has been possible to plan an experimental program to take advantage of this composite of information and at the same time test the credibility of certain critical data by virtue of their acquisition by independent experimenters using differing experimental techniques.

Two rocket launch sites have been set up to accommodate the various rocket payloads. The large rocket launch site located near the Chukuni River, approximately 30 km southeast of the Red Lake area, will handle payloads for ASL, AFGL, and NASA. The small rocket launch site located in the Red Lake area will handle payloads for ASL and NRC of Canada.

Short descriptions of the ASL sponsored rocket payloads are given below. Table 3 gives a brief resume of all large rocket payloads to be flown from the large rocket site, and table 4 gives a resume of the payloads to be flown from the small rocket site.

Large Rocket Payload ASL-SE79A_1 (Payload A)

Sponsor: Atmospheric Sciences Laboratory through the Physical Sciences Laboratory, New Mexico State University.

Number to be Launched: one

Launch Vehicle: Nike-Orion

Sampling Altitude: 60-120 km

Payload Description: The principal mission of this rocket payload is provision of altitude profiles of important minor neutral species. The parameters measured are indicated in the following tabulation:

Measurement	Instrument/Technique
O density	UV resonance lamp
O density (comparative)	5577Å photometer
O_3 density	UV absorption photometer
NO density	UV resonance scattering photometer
OH excitation	Cryogenic infrared radiometer

Measurement	Instrument/Technique
$O_2(^1\Delta_g)$ concentration	Infrared radiometer
Lyman-alpha flux (O_2 density)	Ionization chamber
Solar aspect	Sun sensor
Magnetic aspect	Magnetometer

Large Rocket Payload ASL-SE79B_1 and A12.9A1 (Payload B_1)

Sponsors: Atmospheric Sciences Laboratory through the Physical Sciences Laboratory and Air Force Geophysics Laboratory

Number to be Launched: one

Launch Vehicle: Nike-Orion

Sampling Altitude: 40-120 km

Payload Description: The principal mission objectives for this payload are an electron density profile, photoionization and photodissociation energy input and a profile of mesosopheric density and temperature. The parameters measured are indicated in the following tabulation:

Measurement	Instrument/Technique
Electron density	RF impedance probe
Solar X-rays (1-10Å)	Proportional counter
Precipitated electrons	Scintillation counter
Cosmic rays	Scintillation counter
Solar UV radiation	Photometers (2)
Solar aspect	Sun sensor
Atmospheric density, temperature	Falling sphere

Small Rocket Payload ASL-SE79E (payload E)

Sponsor: Atmospheric Sciences Laboratory through the Physical Sciences Laboratory, New Mexico State University

Number to be Launched: four

Launch Vehicle: Super Arcas

Sampling Altitude: 60-90 km

Payload Description: The principal scientific objectives for these rocket payloads are the measurement of electron density profiles and solar Lyman alpha radiation input to the mesosphere during the eclipse and under noneclipse conditions. These measurements will complement the large rocket experiments and provide more frequent samples of electron density and solar Lyman alpha than would otherwise be possible.

Small Rocket Payload ASL-SE79F (payload F)

Sponsor: Atmospheric Sciences Laboratory through the University of Texas at El Paso

Number to be Launched: six

Launch Vehicle: Super Arcas

Sampling Altitude: 30-85 km

Payload Description: The scientific objective for these rocket payloads is the measurement of positive and negative electrical conductivity, ion mobility, and charge number density in the atmospheric interval sampled. The experimental device used is a Gerdien condenser lowered by parachute (at subsonic speeds) after ejection from the rocket carrier. The operating arrangement of the Gerdien condenser is such that the atmospheric sample to be measured flows at a determined velocity (given by the fall rate of the instrument) through a pair of concentric cylindrical electrodes. In the arrangement used here the inner electrode serves as the charge collector. A voltage applied between the inner and outer electrodes produces an electric field which accelerates the charged particles toward the collecting electrode. The resulting current of collected charged particles, in the presence of a varying voltage, provides information about the electrical conductivity, ion mobility, and charge number density.

Small Rocket Payload ASL-SE79M (Payload M)

Sponsor: Atmospheric Sciences Laboratory and Air Weather Service

Number to be Launched: ten

Launch Vehicle: Super Loki

Sampling Altitude: 30-70 km

Payload Description: The scientific objectives for these rocket payloads are the measurement of winds and of atmospheric temperature in the altitude interval sampled. The instrumentation is carried in a dart launched by the Super Loki rocket. At apogee the instrumentation sensors are ejected and measurements are taken on descent by parachute.

In addition to the rocket borne payloads, a ground based experiment to measure D-region electron densities will also be conducted.

Partial Reflection Experiment

Sponsor: Atmospheric Sciences Laboratory

Sampling Altitude: 60-90 km

Description of the Experiment: The partial reflection experiment is ground based and has as its experimental objective the measurement of D-region electron density profiles throughout the eclipse and for background electron density profiles throughout the eclipse and for background noneclipse conditions. In operation, a low frequency (several megahertz) radar is used to transmit pulses of radiation vertically. Echoes backscattered from the D-region of the ionosphere are received and recorded as functions of pulse transit time. Circular polarization of the transmitted radiation is utilized, and pulses of both right and left hand polarization are employed. Because of the earth's magnetic field, the index of refraction of the ionosphere is different for the two polarization modes. The relative intensities of the waves partially reflected from a given altitude within the ionosphere contain information concerning the electron density at the altitude. This partial reflection technique can be used to measure the density of free electrons, in the ionosphere as a function of altitude from 50 to 100 km. A single frequency of 2.666666 MHz is employed. The partial reflection experiment will be located in Balmertown, near the small rocket launch site, and operated continuously for a period of several days before, during, and following the solar eclipse.

In addition to the measurements detailed above and in tables 3 and 4, other sources of complementary data are available from satellites. The appendix lists the specific physical properties which are to be measured along with the applicable rocket payloads and appropriate complementary satellite measurements.

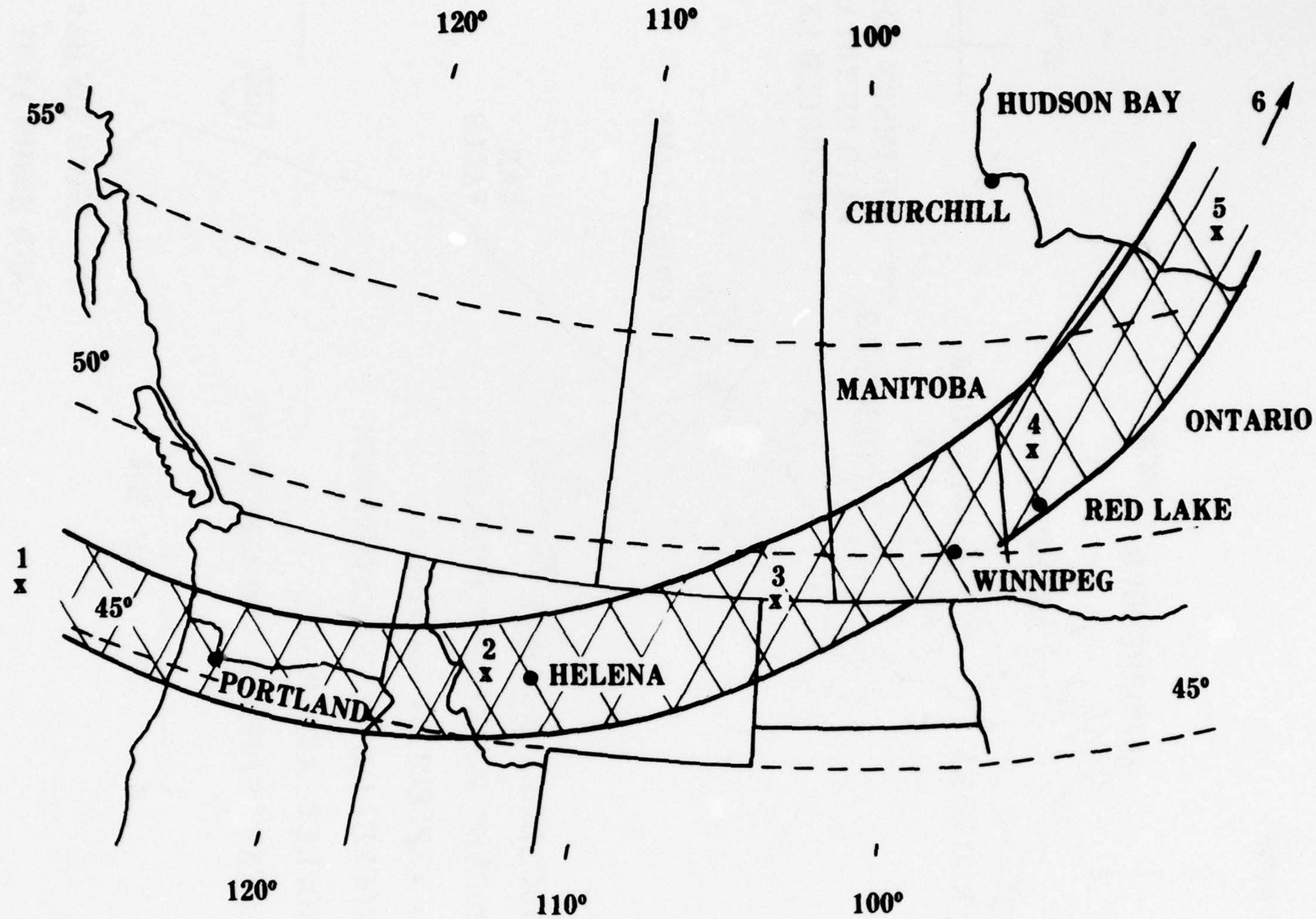


Figure 1. Path of totality for the solar eclipse of 26 February 1979.

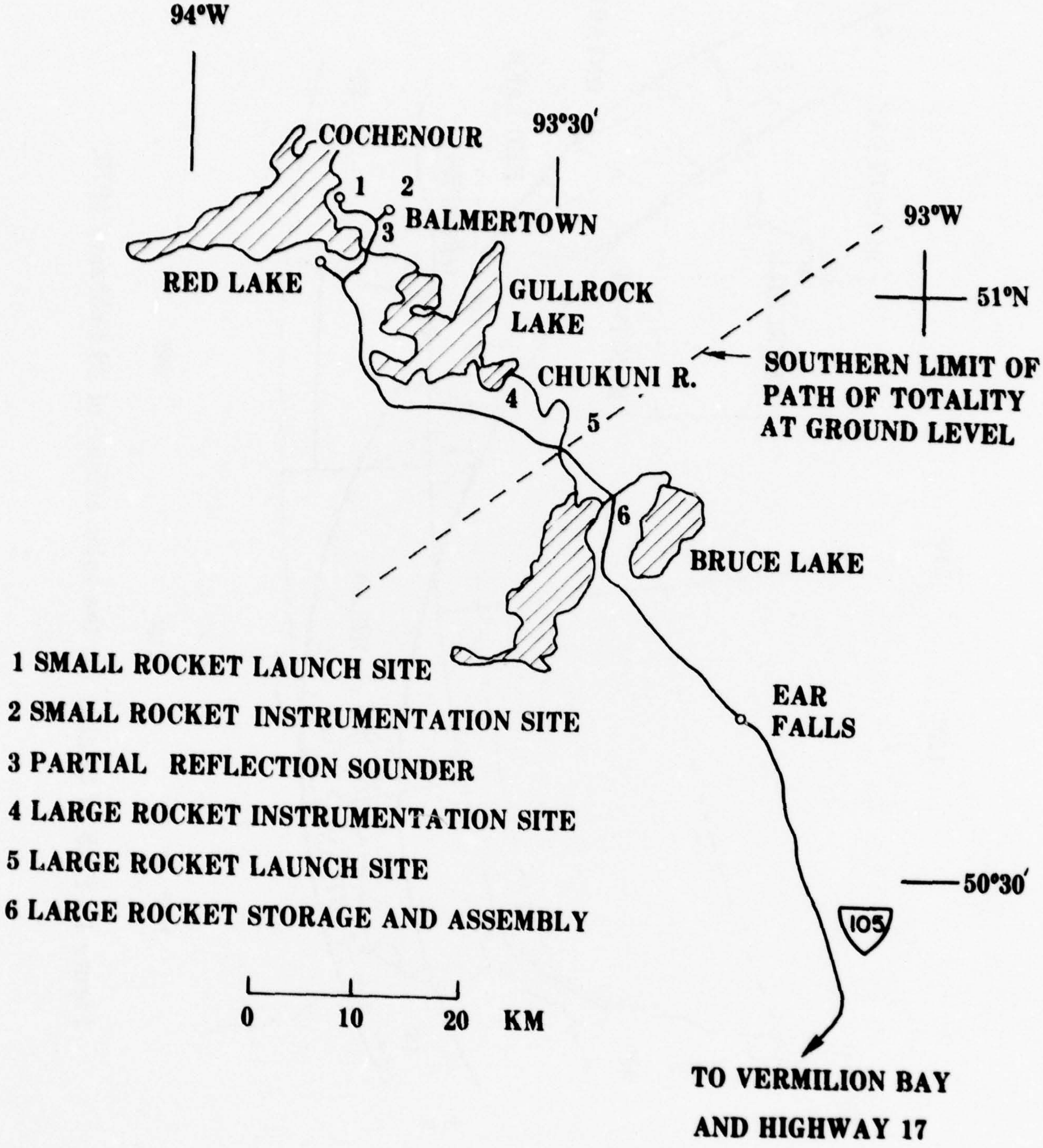


Figure 2. Map of Red Lake area, Ontario, Canada, showing field site locations.

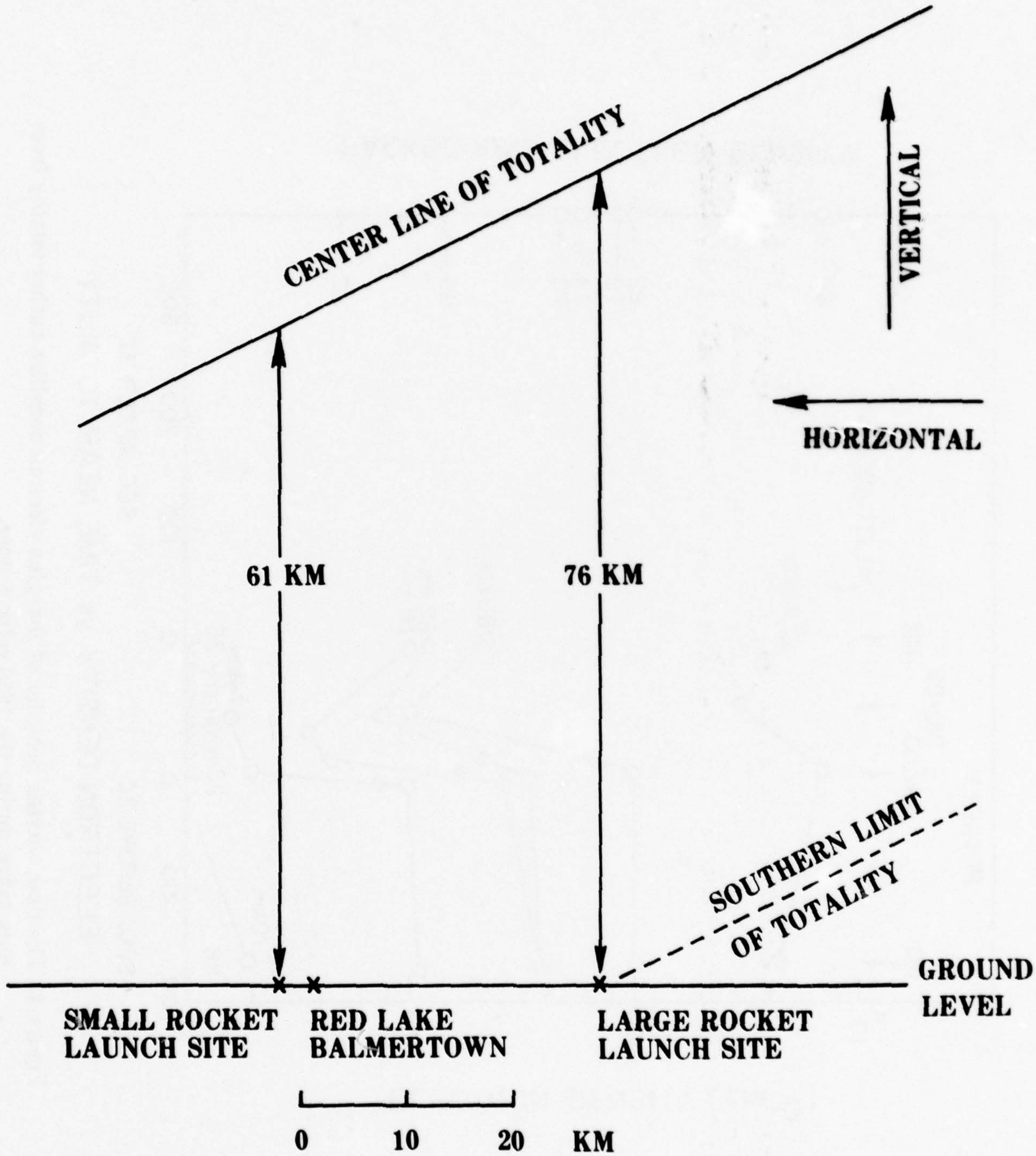


Figure 3. Center line of eclipse totality with respect to field site locations.

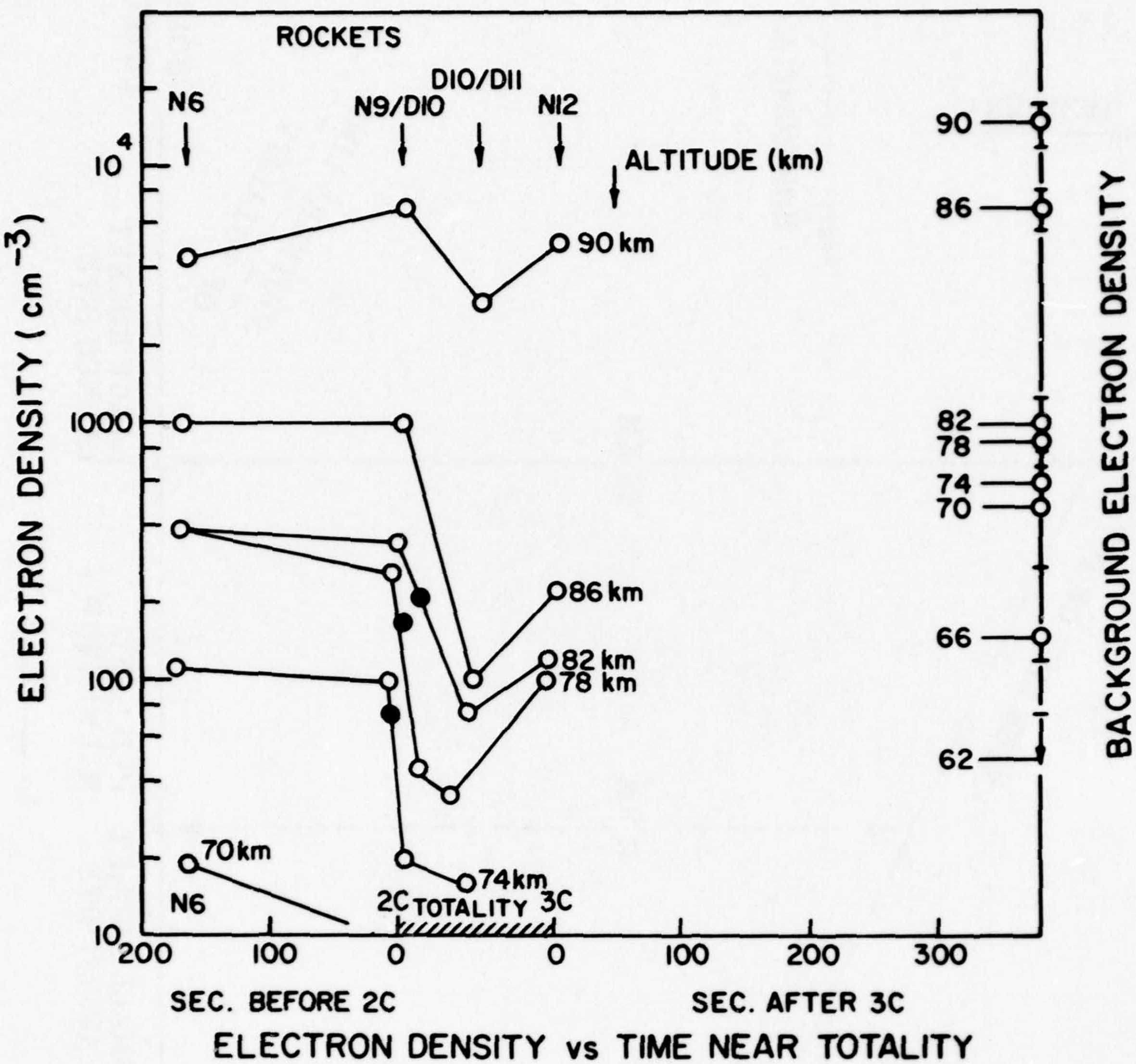


Figure 4. The time varying behavior of D-region electron densities during totality from data taken during the 1966 solar eclipse.

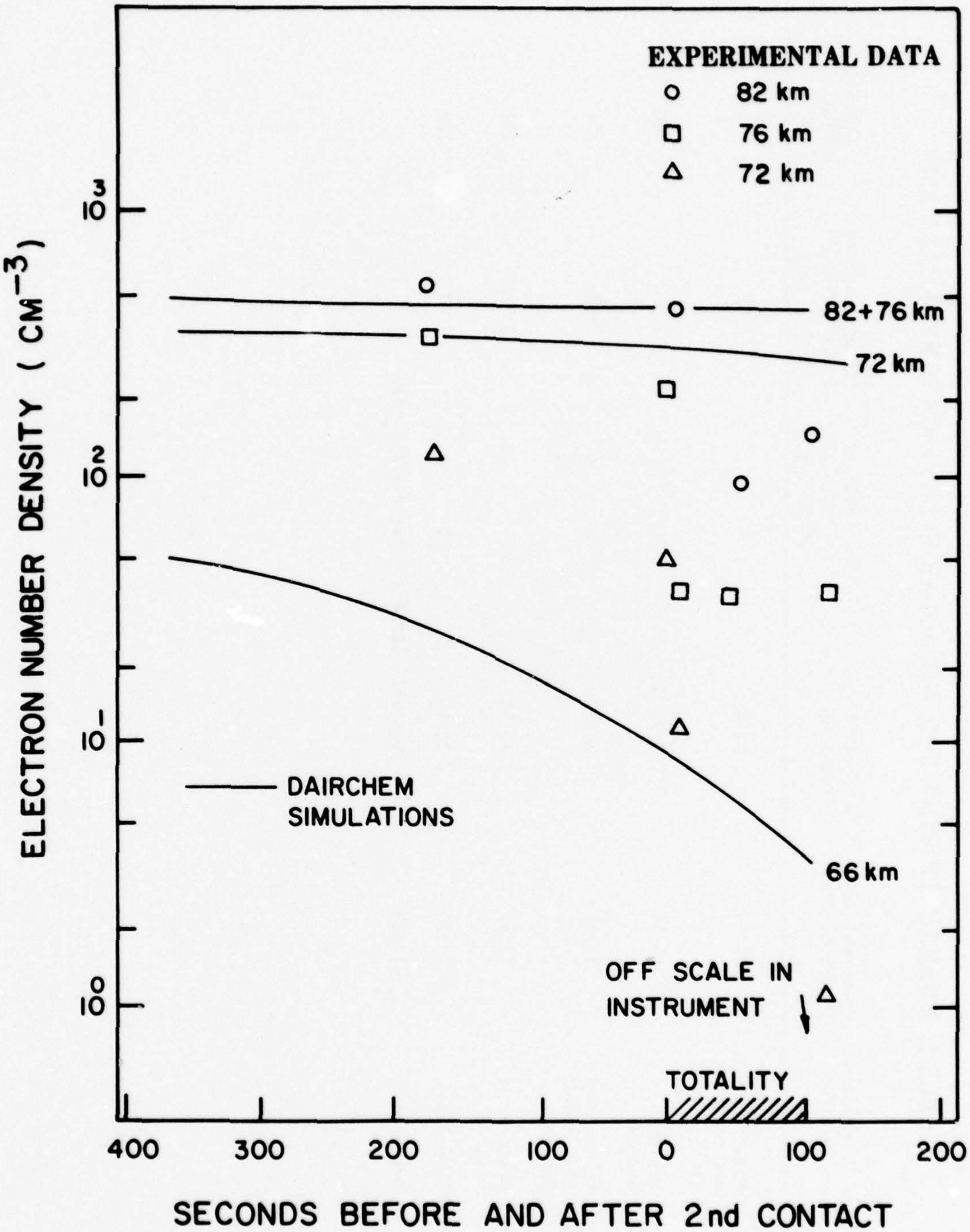


Figure 5. Computer code simulations of D-region electron densities compared with experimental data from the 1966 solar eclipse.

TABLE 1. CHARACTERISTICS FOR THE SOLAR ECLIPSE ON 26 FEBRUARY 1979

Map Location	Geographic Location	Universal Time (hours:minutes)	Local Time (hours:minutes)	Sun Angle (from Horizon) (deg)	Eclipse Duration (minutes:seconds)	Shadow Width (km)
1	Pacific Ocean off coast of Washington	16:10	8:10	5	2:02	249
2	Western Montana	16:25	9:25	20	2:36	303
3	North Dakota US-Canadian Border	16:40	10:40	24	2:49	314
4	Western Ontario	16:55	10:55	26	2:52	304
5	Hudson Bay	17:10	12:10	24	2:47	283
6	Greenland	17:39	Central (total) solar eclipse ends			

TABLE 2. ECLIPSE TIMES AT THE ROCKET LAUNCH SITES

	SMALL ROCKET SITE						LARGE ROCKET SITE					
	Ground Level (hours:minutes:seconds*)			Center Line (61 km) (hours:minutes:seconds*)			Ground Level (hours:minutes:seconds*)			Center Line (76 km) (hours:minutes:seconds*)		
First Contact	15	42	09	15	42	09	15	42	21	15	42	21
Second Contact	15	53	04	16	52	30	16	54	06	16	52	41
Eclipse Maximum	16	53	56	16	53	56	16	54	08	16	54	08
Third Contact	16	54	48	16	55	22	16	54	10	16	55	35
Fourth Contact	18	08	28	18	08	28	18	08	40	18	08	40
Duration of Totality	00	01	44	00	02	53	00	00	04	00	02	54

*Time given is Universal Time: subtract 6 hours for Local Time

TABLE 3. PAYLOADS - LARGE ROCKET LAUNCH SITE

Payload Designation	Sponsor	Measurement	Altitude Range (km)	Launch Time
A	ASL	Solar Lyman alpha radiation. Number densities of O, O_3, NO, OH, and $O_2(^1\Delta_g)$.	60-120	T_2 - 25 min
B_1	ASL AFGL	Neutral atmosphere density and temperature. Electron density. Solar X-ray flux (<10Å). UV flux (1216Å, 2050Å). Ionizing radiations.	40-120	T_2 - 25 min
G	AFGL	Infrared emissions at 3.0μm, 9.6μm, and 10.6μm.	70-120	T_2 - 3 min
C_1	AFGL	Composition and relative density of positive and negative ions. Total ion densities.	50-100	T_2
C_2	AFGL	Same as C_1.	50-100	T_2 + 45 min
B_2	AFGL	Neutral atmosphere density and temperature.	20-100	T_2 + 55 min
N-1	NASA	Composition and relative density of positive ions. Electron density. Direct and scattered solar fluxes at certain wavelengths. Ionizing radiation.	70-120	T_2 - 2 days
N-2	NASA	E and F region electric fields.	100-250	T_2 - 2 min
N-3	NASA	Neutral and ion composition. Electron density and temperature. Airglow. Photoelectrons. Photo-ionization.	100-180	T_2 - 2 min
N-4	NASA	Same as N-1.	70-120	T_2 - 1.5 min
N-5	ARO* ONR NASA	Aerosol properties. Electron attachment/detachment coefficients. Ion conductivities and densities.	35-85	T_2 - 2.5 min
N-6	NASA	Same as N-1, except for negative ion in place of positive ions.	70-120	T_2 + 1 min
N-7	ARO ONR NASA	Same as N-5.	35-85	T_2 + 12 hr or T_2 - 12 hr

*ARO - US Army Research Office; ONR - Office of Naval Research.

T_2 is the time of second contact, i.e., the beginning of totality which lasts 2 min 52 sec at its fullest extent. Launch times are approximate.

TABLE 4. PAYLOADS - SMALL ROCKET LAUNCH SITE

Payload Designation	Sponsor	Measurement	Altitude Range (km)	Launch Time
E (4 payloads)	ASL	Solar Lyman alpha radiation. Electron density.	60-90	T_2 - 1 week to T_2 + 1 day
F (6 payloads)	ASL	Positive and negative ion conductivities.	30-85	T_2 - 1 week to T_2 + 1 day
M (10 payloads)	ASL AWS	Neutral density and temperature.	30-70	T_2 - 1 week to T_2 + 1 day
NRC-1	NRC (Canada)	Vacuum UV of solar corona and prominences. Ozone density. Electron density.	35-120	T_2 - 1 min

REFERENCES

1. Smith, L. G., C. A. Accardo, L. H. Weeks, and P. J. McKinnon, 1963, "Measurements in the Ionosphere During the Solar Eclipse of 20 July 1963," J. Atmospheric Terrest. Phys., 27:803-829.

2. Lootens, H. T., and W. A. Dean, 1970, "D-Region Electron Density Measurements During the Solar Eclipse of 12 November 1966," BRL Report 1464, US Army Ballistic Research Laboratories, Aberdeen Proving Ground, MD.

3. Ballard, H. N., J. S. Randhawa, and W. L. Webb, 1968, "Stratospheric Circulation Response to a Solar Eclipse," R&D Report, ECOM-5189, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

4. Randhawa, J. S., 1968, "Mesospheric Ozone Measurements During a Solar Eclipse," J. Geophys. Res., 73:493-495.

5. Ballard, H. N., R. Valenzuela, M. Izquierdo, J. S. Randhawa, R. Morla, and J. F. Bettle, 1969, "Solar Eclipse: Temperature, Wind, and Ozone in the Stratosphere," J. Geophys. Res., 74:711-713.

6. Hoock, D. W., and M. G. Heaps, 1978, "DAIRCHEM: A Computer Code to Model Ionization-Deionization Processes and Chemistry in the Middle Atmosphere," ASL Internal Report, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

7. Heaps, M. G., F. E. Niles, and R. D. Sears, 1978, "Modeling the Ion Chemistry of the D-Region: A Case Study Based Upon the 1966 Total Solar Eclipse," ASL-TR-0015, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

8. Heaps, M. G., 1978, "The 1979 Solar Eclipse and Validation of D-Region Models," ASL-TR-0002, US Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.

APPENDIX

TYPES OF MEASUREMENTS AND SOURCES OF DATA

FOR THE 1979 SOLAR ECLIPSE PROGRAM

DATA ELEMENT	SOURCE OF MEASUREMENT	TIME OF MEASUREMENT
Electron Density	(1) ASL Payload A	T_2 - 25 minutes
	(2) NASA Payloads	Several times during course of eclipse
	(3) Small Rocket Payload (4 each)	Several times during course of eclipse
	(4) NRC Payload	T_2 - 1 minute
	(5) Ground-based Partial Reflection	continuous
Positive Ion Composition and Density	(1) AFGL Payload C_1	T_2
	(2) AFGL Payload C_2	T_2 + 45 minutes
	(3) NASA Payload N-1	T_2 - 2 days
Negative Ion Composition and Density	(1) AFGL Payload C_1	T_2
	(2) AFGL Payload C_2	T_2 + 45 minutes
	(3) NASA Payload N-6	T_2 - 1.5 minutes
Positive and Negative Charge Conductivity	(1) ASL Small Rocket Payload (6 each)	Several times during course of eclipse
	• Can provide ion mobilities and ion densities	
	• Provides information to low altitudes ($\sim$30 km)	

DATA ELEMENT	SOURCE OF MEASUREMENT	TIME OF MEASUREMENT
Precipitating Electrons	(1) ASL Payload B_1	T_2 - 25 minutes
	(2) NASA Payloads N-1,N-4	T_2 - 1.5 minutes
	(3) NOAA-5 Satellite	Approximately 24 samples per day at latitude of interest
	· 1500 km circular polar orbit	· Directional flux E > 140 kev
Precipitating Protons	(1) ASL Payload B_1	T_2 - 25 minutes
	(2) NASA Payloads N-1,N-4	T_2 - 1.5 minutes
	(3) NOAA-5 Satellite	as noted above
	(4) TIROS-N Satellite	as noted above
Solar X-Rays	(1) ASL-AFGL Payload B_1	T_2 - 25 minutes
	(2) NASA Payloads, N-1,N-4	T_2 - 1.5 minutes
	(3) GOES-1, GOES-2, SMS-1 and SMS-2 Satellites	Continuous monitoring.
	· All in geosynchronous orbits	· 0.5 - 3 Å · 1 - 8 Å
	(4) SOLRAD 11B Satellite	Continuous monitoring
	· 115000 km circular orbit	· 1 - 8 Å
Bremsstrahlung	(1) ASL Payload B_1	T_2 - 25 minutes
Galactic X-Rays	(1) HEAO - 1 Satellite	Continuous mapping; discrete sources and diffuse background
	· 450 km circular orbit	
Galactic Cosmic Rays	(1) ASL Payload B_1	T_2 - 25 minutes
	(2) Ground-based Neutron Monitors	Hourly Available through WDC-A; Calgary station nearby

DATA ELEMENT	SOURCE OF MEASUREMENT	TIME OF MEASUREMENT
Extreme Ultraviolet	(1) NASA Payload N-3	T_2 - 2 minutes
	(2) SOLRAD 11B Satellite	Continuous monitoring
	• 115000 km circular orbit	• 170 - 1050 Å
	(3) AE-E Satellite	Frequent spectral scans
	• 250-390 km orbit	• $\lambda >$ 140 Å
Direct and Scattered Solar Ultraviolet	(1) ASL Payload B_1	T_2 - 25 minutes
	(2) NRC Payload	T_2 - 1 minute
	(3) AE-E Satellite	Frequent spectral scans
		• $\lambda <$ 1850 Å
	(4) SOLRAD 11B Satellite	Continuous monitoring
		• 1080 Å - 1350 Å
		• 1175 Å - 1800 Å
Lyman Alpha	(1) ASL Payload A	T_2 - 25 minutes
	(2) ASL Payload B_1	T_2 - 25 minutes
	(3) NASA Payloads N-1,N-4	T_2 - 1.5 minutes
	(4) NASA Payload N-3	T_2 - 2 minutes
	(5) AE-E Satellites	Frequent spectral scans
		• Specific measurement at 1216 Å
	(6) ASL Small Rocket (4 each)	Several times during course of eclipse

DATA ELEMENT	SOURCE OF MEASUREMENT	TIME OF MEASUREMENT
Lyman Beta	(1) NASA Payload N-3	T_2 - 2 minutes
	(2) AE-E Satellite	Frequent spectral scans · Specific measurement at 1026 Å
Infrared Radiation from Atmospheric Molecules	(1) AFGL Payload G	T_2 - 3 minutes
	(2) USU Field-Widened Inferometer	Continuous
Minor Neutral	(1) ASL Payload A	T_2 - 25 minutes · $O, O_3, NO, OH, O_2(^1\Delta_g)$
	(2) NASA Payloads, N-1,N-4	T_2 - 1.5 minutes · O_3
	(3) DMSP-F2 Satellite (Block 5)	Early morning and local noon scans · O_3 through stratosphere · H_2O through stratosphere
Atmospheric Density	(1) AFGL Payload B_1	T_2 - 25 minutes
	(2) AFGL Payload B_2	T_2 + minutes
	(3) Rocket Payloads equipped with Lyman alpha detectors	Several times during course of eclipse · Altitude profiles of Lyman alpha radiation can provide (through calculation) altitude profiles of $[O_2]$, and hence, total density.

DATA ELEMENT	SOURCE OF MEASUREMENT	TIME OF MEASUREMENT
Atmospheric Temperature	(1) AFGL Payload B_1	T_2 - 25 minutes
	(2) AFGL Payload B_2	T_2 + 55 minutes
	(3) ASL Small Rocket Payload (10 each)	Several times during course of elcipse
	(4) DMSPF-2 Satellite (Block 5)	Early morning and local noon
	· 850 km circular orbit	· Temperature through stratosphere
	(5) TIROS N Satellite	Approximately 30 samples per day at latitudes of interest
	· 500 km circular orbit	· Temperature through stratosphere
Aerosols	(1) NASA Payloads, N-5,N-7	T_2 - 2.5 minutes
		$T_2 \pm$ 12 hours
		· Instrumented with flashing visible and UV lamps and a collecting electrode. Parachute deployed

DISTRIBUTION LIST

Dr. Frank D. Eaton
Geophysical Institute
University of Alaska
Fairbanks, AK 99701

Commander
US Army Aviation Center
ATTN: ATZQ-D-MA
Fort Rucker, AL 36362

Chief, Atmospheric Sciences Div
Code ES-81
NASA
Marshall Space Flight Center,
AL 35812

Commander
US Army Missile R&D Command
ATTN: DRDMI-CGA (B. W. Fowler)
Redstone Arsenal, AL 35809

Redstone Scientific Information Center
ATTN: DRDMI-TBD
US Army Missile R&D Command
Redstone Arsenal, AL 35809

Commander
US Army Missile R&D Command
ATTN: DRDMI-TEM (R. Haraway)
Redstone Arsenal, AL 35809

Commander
US Army Missile R&D Command
ATTN: DRDMI-TRA (Dr. Essenwanger)
Redstone Arsenal, AL 35809

Commander
HQ, Fort Huachuca
ATTN: Tech Ref Div
Fort Huachuca, AZ 85613

Commander
US Army Intelligence Center & School
ATTN: ATSI-CD-MD
Fort Huachuca, AZ 85613

Commander
US Army Yuma Proving Ground
ATTN: Technical Library
Bldg 2100
Yuma, AZ 85364

Naval Weapons Center (Code 3173)
ATTN: Dr. A. Shlanta
China Lake, CA 93555

Sylvania Elec Sys Western Div
ATTN: Technical Reports Library
PO Box 205
Mountain View, CA 94040

Geophysics Officer
PMTC Code 3250
Pacific Missile Test Center
Point Mugu, CA 93042

Commander
Naval Ocean Systems Center (Code 4473)
ATTN: Technical Library
San Diego, CA 92152

Meteorologist in Charge
Kwajalein Missile Range
PO Box 67
APO San Francisco, 96555

Director
NOAA/ERL/APCL R31
RB3-Room 567
Boulder, CO 80302

Library-R-51-Tech Reports
NOAA/ERL
320 S. Broadway
Boulder, CO 80302

National Center for Atmos Research
NCAR Library
PO Box 3000
Boulder, CO 80307

B. Girardo
Bureau of Reclamation
E&R Center, Code 1220
Denver Federal Center, Bldg 67
Denver, CO 80225

National Weather Service
National Meteorological Center
W321, WWB, Room 201
ATTN: Mr. Quiroz
Washington, DC 20233

Mil Assistant for Atmos Sciences
Ofc of the Undersecretary of Defense
for Rsch & Engr/E&LS - Room 3D129
The Pentagon
Washington, DC 20301

Defense Communications Agency
Technical Library Center
Code 205
Washington, DC 20305

Director
Defense Nuclear Agency
ATTN: Technical Library
Washington, DC 20305

HQDA (DAEN-RDM/Dr. de Percin)
Washington, DC 20314

Director
Naval Research Laboratory
Code 5530
Washington, DC 20375

Commanding Officer
Naval Research Laboratory
Code 2627
Washington, DC 20375

Dr. J. M. MacCallum
Naval Research Laboratory
Code 1409
Washington, DC 20375

The Library of Congress
ATTN: Exchange & Gift Div
Washington, DC 20540
2

Head, Atmos Rsch Section
Div Atmospheric Science
National Science Foundation
1800 G. Street, NW
Washington, DC 20550

CPT Hugh Albers, Exec Sec
Interdept Committee on Atmos Science
National Science Foundation
Washington, DC 20550

Director, Systems R&D Service
Federal Aviation Administration
ATTN: ARD-54
2100 Second Street, SW
Washington, DC 20590

ADTC/DLODL
Eglin AFB, FL 32542

Naval Training Equipment Center
ATTN: Technical Library
Orlando, FL 32813

Det 11, 2WS/OI
ATTN: Maj Orondorff
Patrick AFB, FL 32925

USAFETAC/CB
Scott AFB, IL 62225

HQ, ESD/TOSI/S-22
Hanscom AFB, MA 01731

Air Force Geophysics Laboratory
ATTN: LCB (A. S. Carten, Jr.)
Hanscom AFB, MA 01731

Air Force Geophysics Laboratory
ATTN: LYD
Hanscom AFB, MA 01731

Meteorology Division
AFGL/LY
Hanscom AFB, MA 01731

US Army Liaison Office
MIT-Lincoln Lab, Library A-082
PO Box 73
Lexington, MA 02173

Director
US Army Ballistic Rsch Lab
ATTN: DRDAR-BLB (Dr. G. E. Keller)
Aberdeen Proving Ground, MD 21005

Commander
US Army Ballistic Rsch Lab
ATTN: DRDAR-BLP
Aberdeen Proving Ground, MD 21005

Director
US Army Armament R&D Command
Chemical Systems Laboratory
ATTN: DRDAR-CLJ-I
Aberdeen Proving Ground, MD 21010

Chief CB Detection & Alarms Div
Chemical Systems Laboratory
ATTN: DRDAR-CLC-CR (H. Tannenbaum)
Aberdeen Proving Ground, MD 21010

Commander
Harry Diamond Laboratories
ATTN: DELHD-CO
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-AP
2800 Powder Mill Road
Adelphi, MD 20783
2

Commander
ERADCOM
ATTN: DRDEL-CG/DRDEL-DC/DRDEL-CS
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-CT
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-EA
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-PA/DRDEL-ILS/DRDEL-E
2800 Powder Mill Road
Adelphi, MD 20783

Commander
ERADCOM
ATTN: DRDEL-PAO (S. Kimmel)
2800 Powder Mill Road
Adelphi, MD 20783

Chief
Intelligence Materiel Dev & Support Ofc
ATTN: DELEW-WL-I
Bldg 4554
Fort George G. Meade, MD 20755

Acquisitions Section, IRDB-D823
Library & Info Service Div, NOAA
6009 Executive Blvd
Rockville, MD 20852

Naval Surface Weapons Center
White Oak Library
Silver Spring, MD 20910

The Environmental Research
Institute of MI
ATTN: IRIA Library
PO Box 8618
Ann Arbor, MI 48107

Mr. William A. Main
USDA Forest Service
1407 S. Harrison Road
East Lansing, MI 48823

Dr. A. D. Belmont
Research Division
PO Box 1249
Control Data Corp
Minneapolis, MN 55440

Director
Naval Oceanography & Meteorology
NSTL Station
Bay St Louis, MS 39529

Director
US Army Engr Waterways Experiment Sta
ATTN: Library
PO Box 631
Vicksburg, MS 39180

Environmental Protection Agency
Meteorology Laboratory
Research Triangle Park, NC 27711

US Army Research Office
ATTN: DRXRO-PP
PO Box 12211
Research Triangle Park, NC 27709

Commanding Officer
US Army Armament R&D Command
ATTN: DRDAR-TSS Bldg 59
Dover, NJ 07801

Commander
HQ, US Army Avionics R&D Activity
ATTN: DAVAA-O
Fort Monmouth, NJ 07703

Commander/Director
US Army Combat Surveillance & Target
Acquisition Laboratory
ATTN: DELCS-D
Fort Monmouth, NJ 07703

Commander
US Army Electronics R&D Command
ATTN: DELCS-S
Fort Monmouth, NJ 07703

US Army Materiel Systems
Analysis Activity
ATTN: DRXSY-MP
Aberdeen Proving Ground, MD 21005

Director
US Army Electronics Technology &
Devices Laboratory
ATTN: DELET-D
Fort Monmouth, NJ 07703

Commander
US Army Electronic Warfare Laboratory
ATTN: DELEW-D
Fort Monmouth, NJ 07703

Commander
US Army Night Vision &
Electro-Optics Laboratory
ATTN: DELNV-L (Dr. Rudolf Buser)
Fort Monmouth, NJ 07703

Commander
ERADCOM Technical Support Activity
ATTN: DELSD-L
Fort Monmouth, NJ 07703

Project Manager, FIREFINDER
ATTN: DRCPM-FF
Fort Monmouth, NJ 07703

Project Manager, REMBASS
ATTN: DRCPM-RBS
Fort Monmouth, NJ 07703

Commander
US Army Satellite Comm Agency
ATTN: DRCPM-SC-3
Fort Monmouth, NJ 07703

Commander
ERADCOM Scientific Advisor
ATTN: DRDEL-SA
Fort Monmouth, NJ 07703

6585 TG/WE
Holloman AFB, NM 88330

AFWL/WE
Kirtland, AFB, NM 87117

AFWL/Technical Library (SUL)
Kirtland AFB, NM 87117

Commander
US Army Test & Evaluation Command
ATTN: STEWS-AD-L
White Sands Missile Range, NM 88002

Rome Air Development Center
ATTN: Documents Library
TSLD (Bette Smith)
Griffiss AFB, NY 13441

Commander
US Army Tropic Test Center
ATTN: STETC-TD (Info Center)
APO New York 09827

Commandant
US Army Field Artillery School
ATTN: ATSF-CD-R (Mr. Farmer)
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: ATSF-CF-R
Fort Sill, OK 73503

Director CFD
US Army Field Artillery School
ATTN: Met Division
Fort Sill, OK 73503

Commandant
US Army Field Artillery School
ATTN: Morris Swett Library
Fort Sill, OK 73503

Commander
US Army Dugway Proving Ground
ATTN: MT-DA-L
Dugway, UT 84022

Dr. C. R. Sreedrahan
Research Associates
Utah State University, UNC 48
Logan, UT 84322

Inge Dirmhirn, Professor
Utah State University, UNC 48
Logan, UT 84322

Defense Documentation Center
ATTN: DDC-TCA
Cameron Station Bldg 5
Alexandria, VA 22314
12

Commanding Officer
US Army Foreign Sci & Tech Center
ATTN: DRXST-IS1
220 7th Street, NE
Charlottesville, VA 22901

Naval Surface Weapons Center
Code G65
Dahlgren, VA 22448

Commander
US Army Night Vision
& Electro-Optics Lab
ATTN: DELNV-D
Fort Belvoir, VA 22060

Commander and Director
US Army Engineer Topographic Lab
ETL-TD-MB
Fort Belvoir, VA 22060

Director
Applied Technology Lab
DAVDL-EU-TSD
ATTN: Technical Library
Fort Eustis, VA 23604

Department of the Air Force
OL-C, 5WW
Fort Monroe, VA 23651

Department of the Air Force
5WW/DN
Langley AFB, VA 23665

Director
Development Center MCDEC
ATTN: Firepower Division
Quantico, VA 22134

US Army Nuclear & Chemical Agency
ATTN: MONA-WE
Springfield, VA 22150

Director
US Army Signals Warfare Laboratory
ATTN: DELSW-OS (Dr. R. Burkhardt)
Vint Hill Farms Station
Warrenton, VA 22186

Commander
US Army Cold Regions Test Center
ATTN: STECR-OP-PM
APO Seattle, WA 98733

Dr. John L. Walsh
Code 5560
Navy Research Lab
Washington, DC 20375

Commander
TRASANA
ATTN: ATAA-PL
(Dolores Anguiano)
White Sands Missile Range, NM 88002

Commander
US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-M (Mr. Paul Carlson)
Dugway, UT 84022

Commander
US Army Dugway Proving Ground
ATTN: STEDP-MT-DA-T
(Mr. William Peterson)
Dugway, UT 84022

Commander
USATRADOC
ATTN: ATCD-SIE
Fort Monroe, VA 23651

Commander
USATRADOC
ATTN: ATCD-CF
Fort Monroe, VA 23651

Commander
USATRADOC
ATTN: Tech Library
Fort Monroe, VA 23651

ATMOSPHERIC SCIENCES RESEARCH PAPERS

1. Lindberg, J.D., "An Improvement to a Method for Measuring the Absorption Coefficient of Atmospheric Dust and other Strongly Absorbing Powders," ECOM-5565, July 1975.
2. Avara, Elton, P., "Mesoscale Wind Shears Derived from Thermal Winds," ECOM-5566, July 1975.
3. Gomez, Richard B., and Joseph H. Pierluissi, "Incomplete Gamma Function Approximation for King's Strong-Line Transmittance Model," ECOM-5567, July 1975.
4. Blanco, A.J., and B.F. Engebos, "Ballistic Wind Weighting Functions for Tank Projectiles," ECOM-5568, August 1975.
5. Taylor, Fredrick J., Jack Smith, and Thomas H. Pries, "Crosswind Measurements through Pattern Recognition Techniques," ECOM-5569, July 1975.
6. Walters, D.L., "Crosswind Weighting Functions for Direct-Fire Projectiles," ECOM-5570, August 1975.
7. Duncan, Louis D., "An Improved Algorithm for the Iterated Minimal Information Solution for Remote Sounding of Temperature," ECOM-5571, August 1975.
8. Robbiani, Raymond L., "Tactical Field Demonstration of Mobile Weather Radar Set AN/TPS-41 at Fort Rucker, Alabama," ECOM-5572, August 1975.
9. Miers, B., G. Blackman, D. Langer, and N. Lorimier, "Analysis of SMS/GOES Film Data," ECOM-5573, September 1975.
10. Manquero, Carlos, Louis Duncan, and Rufus Bruce, "An Indication from Satellite Measurements of Atmospheric CO_2 Variability," ECOM-5574, September 1975.
11. Petracca, Carmine, and James D. Lindberg, "Installation and Operation of an Atmospheric Particulate Collector," ECOM-5575, September 1975.
12. Avara, Elton P., and George Alexander, "Empirical Investigation of Three Iterative Methods for Inverting the Radiative Transfer Equation," ECOM-5576, October 1975.
13. Alexander, George D., "A Digital Data Acquisition Interface for the SMS Direct Readout Ground Station — Concept and Preliminary Design," ECOM-5577, October 1975.
14. Cantor, Israel, "Enhancement of Point Source Thermal Radiation Under Clouds in a Nonattenuating Medium," ECOM-5578, October 1975.
15. Norton, Colburn, and Glenn Hoidale, "The Diurnal Variation of Mixing Height by Month over White Sands Missile Range, N.M," ECOM-5579, November 1975.
16. Avara, Elton P., "On the Spectrum Analysis of Binary Data," ECOM-5580, November 1975.
17. Taylor, Fredrick J., Thomas H. Pries, and Chao-Huan Huang, "Optimal Wind Velocity Estimation," ECOM-5581, December 1975.
18. Avara, Elton P., "Some Effects of Autocorrelated and Cross-Correlated Noise on the Analysis of Variance," ECOM-5582, December 1975.
19. Gillespie, Patti S., R.L. Armstrong, and Kenneth O. White, "The Spectral Characteristics and Atmospheric CO_2 Absorption of the Ho^{+3}:YLF Laser at 2.05μm," ECOM-5583, December 1975.
20. Novlan, David J. "An Empirical Method of Forecasting Thunderstorms for the White Sands Missile Range," ECOM-5584, February 1976.
21. Avara, Elton P., "Randomization Effects in Hypothesis Testing with Autocorrelated Noise," ECOM-5585, February 1976.
22. Watkins, Wendell R., "Improvements in Long Path Absorption Cell Measurement," ECOM-5586, March 1976.
23. Thomas, Joe, George D. Alexander, and Marvin Dubbin, "SATTEL — An Army Dedicated Meteorological Telemetry System," ECOM-5587. March 1976.
24. Kennedy, Bruce W., and Delbert Bynum, "Army User Test Program for the RDT&E-XM-75 Meteorological Rocket," ECOM-5588, April 1976.

25. Barnett, Kenneth M., "A Description of the Artillery Meteorological Comparisons at White Sands Missle Range, October 1974 - December 1974 ('PASS' - Prototype Artillery [Meteorological] Subsystem)," ECOM-5589, April 1976.
26. Miller, Walter B., "Preliminary Analysis of Fall-of-Shot From Project 'PASS'," ECOM-5590, April 1976.
27. Avara, Elton P., "Error Analysis of Minimum Information and Smith's Direct Methods for Inverting the Radiative Transfer Equation," ECOM-5591, April 1976.
28. Yee, Young P., James D. Horn, and George Alexander, "Synoptic Thermal Wind Calculations from Radiosonde Observations Over the Southwestern United States," ECOM-5592, May 1976.
29. Duncan, Louis D., and Mary Ann Seagraves, "Applications of Empirical Corrections to NOAA-4 VTPR Observations," ECOM-5593, May 1976.
30. Miers, Bruce T., and Steve Weaver, "Applications of Meterological Satellite Data to Weather Sensitive Army Operations,"ECOM-5594, May 1976.
31. Sharenow, Moses, "Redesign and Improvement of Balloon ML-566," ECOM-5595, June, 1976.
32. Hansen, Frank V., "The Depth of the Surface Boundary Layer," ECOM-5596, June 1976.
33. Pinnick, R.G., and E.B. Stenmark, "Response Calculations for a Commercial Light-Scattering Aerosol Counter," ECOM-5597, July 1976.
34. Mason, J., and G.B. Hoidale, "Visibility as an Estimator of Infrared Transmittance," ECOM-5598, July 1976.
35. Bruce, Rufus E., Louis D. Duncan, and Joseph H. Pierluissi, "Experimental Study of the Relationship Between Radiosonde Temperatures and Radiometric-Area Temperatures," ECOM-5599, August 1976.
36. Duncan, Louis D., "Stratospheric Wind Shear Computed from Satellite Thermal Sounder Measurements," ECOM-5800, September 1976.
37. Taylor, F., P. Mohan, P. Joseph and T. Pries, "An All Digital Automated Wind Measurement System," ECOM-5801, September 1976.
38. Bruce, Charles, "Development of Spectrophones for CW and Pulsed Radiation Sources," ECOM-5802, September 1976.
39. Duncan, Louis D., and Mary Ann Seagraves,"Another Method for Estimating Clear Column Radiances," ECOM-5803, October 1976.
40. Blanco, Abel J., and Larry E. Taylor, "Artillery Meteorological Analysis of Project Pass," ECOM-5804, October 1976.
41. Miller, Walter, and Bernard Engebos," A Mathematical Structure for Refinement of Sound Ranging Estimates," ECOM-5805, November, 1976.
42. Gillespie, James B., and James D. Lindberg, "A Method to Obtain Diffuse Reflectance Measurements from 1.0 to 3.0 μm Using a Cary 171 Spectrophotometer," ECOM-5806, November 1976.
43. Rubio, Roberto, and Robert O. Olsen,"A Study of the Effects of Temperature Variations on Radio Wave Absorption,"ECOM-5807, November 1976.
44. Ballard, Harold N., "Temperature Measurements in the Stratosphere from Balloon-Borne Instrument Platforms, 1968-1975," ECOM-5808, December 1976.
45. Monahan, H.H., "An Approach to the Short-Range Prediction of Early Morning Radiation Fog," ECOM-5809, January 1977.
46. Engebos, Bernard Francis, "Introduction to Multiple State Multiple Action Decision Theory and Its Relation to Mixing Structures," ECOM-5810, January 1977.
47. Low, Richard D.H.,"Effects of Cloud Particles on Remote Sensing from Space in the 10-Micrometer Infrared Region," ECOM-5811, January 1977.
48. Bonner, Robert S., and R. Newton, "Application of the AN/GVS-5 Laser Rangefinder to Cloud Base Height Measurements," ECOM-5812, February 1977.
49. Rubio, Roberto, "Lidar Detection of Subvisible Reentry Vehicle Erosive Atmospheric Material," ECOM-5813, March 1977.
50. Low, Richard D.H., and J.D. Horn, "Mesoscale Determination of Cloud-Top Height: Problems and Solutions," ECOM-5814, March 1977.

51. Duncan, Louis D., and Mary Ann Seagraves, "Evaluation of the NOAA-4 VTPR Thermal Winds for Nuclear Fallout Predictions," ECOM-5815, March 1977.
52. Randhawa, Jagir S., M. Izquierdo, Carlos McDonald and Zvi Salpeter, "Stratospheric Ozone Density as Measured by a Chemiluminescent Sensor During the Stratcom VI-A Flight," ECOM-5816, April 1977.
53. Rubio, Roberto, and Mike Izquierdo, "Measurements of Net Atmospheric Irradiance in the 0.7- to 2.8-Micrometer Infrared Region," ECOM-5817, May 1977.
54. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson Consultant for Chemical Kinetics, "Calculation of Selected Atmospheric Composition Parameters for the Mid-Latitude, September Stratosphere," ECOM-5818, May 1977.
55. Mitchell, J.D., R.S. Sagar, and R.O. Olsen, "Positive Ions in the Middle Atmosphere During Sunrise Conditions," ECOM-5819, May 1977.
56. White, Kenneth O., Wendell R. Watkins, Stuart A. Schleusener, and Ronald L. Johnson, "Solid-State Laser Wavelength Identification Using a Reference Absorber," ECOM-5820, June 1977.
57. Watkins, Wendell R., and Richard G. Dixon, "Automation of Long-Path Absorption Cell Measurements," ECOM-5821, June 1977.
58. Taylor, S.E., J.M. Davis, and J.B. Mason, "Analysis of Observed Soil Skin Moisture Effects on Reflectance," ECOM-5822, June 1977.
59. Duncan, Louis D. and Mary Ann Seagraves, "Fallout Predictions Computed from Satellite Derived Winds," ECOM-5823. June 1977.
60. Snider, D.E., D.G. Murcray, F.H. Murcray, and W.J. Williams, "Investigation of High-Altitude Enhanced Infrared Backround Emissions" (U), SECRET, ECOM-5824, June 1977.
61. Dubbin, Marvin H. and Dennis Hall, "Synchronous Meteorlogical Satellite Direct Readout Ground System Digital Video Electronics," ECOM-5825, June 1977.
62. Miller, W., and B. Engebos, "A Preliminary Analysis of Two Sound Ranging Algorithms," ECOM-5826, July 1977.
63. Kennedy, Bruce W., and James K. Luers, "Ballistic Sphere Techniques for Measuring Atomspheric Parameters," ECOM-5827, July 1977.
64. Duncan, Louis D., "Zenith Angle Variation of Satellite Thermal Sounder Measurements," ECOM-5828, August 1977.
65. Hansen, Frank V., "The Critical Richardson Number," ECOM-5829, September 1977.
66. Ballard, Harold N., and Frank P. Hudson (Compilers), "Stratospheric Composition Balloon-Borne Experiment," ECOM-5830, October 1977.
67. Barr, William C., and Arnold C. Peterson, "Wind Measuring Accuracy Test of Meteorological Systems," ECOM-5831, November 1977.
68. Ethridge, G.A. and F.V. Hansen, "Atmospheric Diffusion: Similarity Theory and Empirical Derivations for Use in Boundary Layer Diffusion Problems," ECOM-5832, November 1977.
69. Low, Richard D.H., "The Internal Cloud Radiation Field and a Technique for Determining Cloud Blackness," ECOM-5833, December 1977.
70. Watkins, Wendell R., Kenneth O. White, Charles W. Bruce, Donald L. Walters, and James D. Lindberg, "Measurements Required for Prediction of High Energy Laser Transmission," ECOM-5834, December 1977.
71. Rubio, Robert, "Investigation of Abrupt Decreases in Atmospherically Backscattered Laser Energy," ECOM-5835. December 1977.
72. Monahan, H.H. and R.M. Cionco, "An Interpretative Review of Existing Capabilities for Measuring and Forecasting Selected Weather Variables (Emphasizing Remote Means)," ASL-TR-0001, January 1978.
73. Heaps, Melvin G., "The 1979 Solar Eclipse and Validation of D-Region Models," ASL-TR-0002. March 1978.

74. Jennings, S.G., and J.B. Gillespie, "M.I.E. Theory Sensitivity Studies - The Effects of Aerosol Complex Refractive Index and Size Distribution Variations on Extinction and Absorption Coefficients Part II: Analysis of the Computational Results," ASL-TR-0003, March 1978.

75. White, Kenneth O. et al, "Water Vapor Continuum Absorption in the 3.5μm to 4.0μm Region," ASL-TR-0004, March 1978.

76. Olsen, Robert O., and Bruce W. Kennedy, "ABRES Pretest Atmospheric Measurements," ASL-TR-0005, April 1978.

77. Ballard, Harold N., Jose M. Serna, and Frank P. Hudson, "Calculation of Atmospheric Composition in the High Latitude September Stratosphere," ASL-TR-0006, May 1978.

78. Watkins, Wendell R. et al, "Water Vapor Absorption Coefficients at HF Laser Wavelengths," ASL-TR-0007, May 1978.

79. Hansen, Frank V., "The Growth and Prediction of Nocturnal Inversions," ASL-TR-0008, May 1978.

80. Samuel, Christine, Charles Bruce, and Ralph Brewer, "Spectrophone Analysis of Gas Samples Obtained at Field Site," ASL-TR-0009, June 1978.

81. Pinnick, R.G. et al., "Vertical Structure in Atmospheric Fog and Haze and its Effects on IR Extinction," ASL-TR-0010, July 1978.

82. Low, Richard D.H., Louis D. Duncan, and Richard B. Gomez, "The Microphysical Basis of Fog Optical Characterization," ASL-TR-0011, August 1978.

83. Heaps, Melvin G., "The Effect of a Solar Proton Event on the Minor Neutral Constituents of the Summer Polar Mesosphere," ASL-TR-0012, August 1978.

84. Mason, James B., "Light Attenuation in Falling Snow," ASL-TR-0013, August 1978.

85. Blanco, Abel J., "Long-Range Artillery Sound Ranging: "PASS" Meteorological Application," ASL-TR-0014, September 1978.

86. Heaps, M.G., and F.E. Niles, "Modeling the Ion Chemistry of the D-Region: A case Study Based Upon the 1966 Total Solar Eclipse," ASL-TR-0015, September 1978.

87. Jennings, S.G., and R.G. Pinnick, "Effects of Particulate Complex Refractive Index and Particle Size Distribution Variations on Atmospheric Extinction and Absorption for Visible Through Middle-Infrared Wavelengths," ASL-TR-0016, September 1978.

88. Watkins, Wendell R., Kenneth O. White, Lanny R. Bower, and Brian Z. Sojka, " Pressure Dependence of the Water Vapor Continuum Absorption in the 3.5- to 4.0-Micrometer Region," ASL-TR-0017, September 1978.

89. Miller, W.B., and B.F. Engebos, "Behavior of Four Sound Ranging Techniques in an Idealized Physical Enviroment," ASL-TR-0018, September 1978.

90. Gomez, Richard G., "Effectiveness Studies of the CBU-88/B Bomb, Cluster, Smoke Weapon" (U), CONFIDENTIAL ASL-TR-0019, September 1978.

91. Miller, August, Richard C. Shirkey, and Mary Ann Seagraves, "Calculation of Thermal Emission from Aerosols Using the Doubling Technique," ASL-TR-0020, November, 1978.

92. Lindberg, James D. et al., "Measured Effects of Battlefield Dust and Smoke on Visible, Infrared, and Millimeter Wavelengths Propagation: A Preliminary Report on Dusty Infrared Test-I (DIRT-I)," ASL-TR-0021, January 1979.

93. Kennedy, Bruce W., Arthur Kinghorn, and B.R. Hixon, "Engineering Flight Tests of Range Meteorological Sounding System Radiosonde," ASL-TR-0022, February 1979.

94. Rubio, Roberto, and Don Hoock, "Microwave Effective Earth Radius Factor Variability at Wiesbaden and Balboa," ASL-TR-0023, February 1979.

95. Low, Richard D.H., "A Theoretical Investigation of Cloud/Fog Optical Properties and Their Spectral Correlations," ASL-TR-0024, February 1979.

96. Pinnick, R.G., and H.J. Auvermann, "Response Characteristics of Knollenberg Light-Scattering Aerosol Counters," ASL-TR-0025, February 1979.

97. Heaps, Melvin G., Robert O. Olsen, and Warren W. Berning, "Solar Eclipse 1979, Atmospheric Sciences Laboratory Program Overview," ASL-TR-0026 February 1979

✩ U.S. GOVERNMENT PRINTING OFFICE: 1979 677-017/38

DEPARTMENT OF THE ARMY
US ARMY ATMOSPHERIC SCIENCES LABORATORY
DELAS-DM-A
WHITE SANDS MISSILE RANGE, NM 88002

OFFICAL BUSINESS
Penalty For Private Use, $300

POSTAGE AND FEES PAID
DEPARTMENT OF THE ARMY
DOD 314

U.S. MAIL